

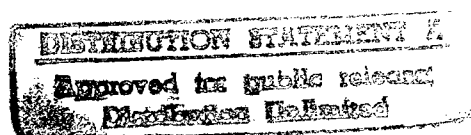
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# ***JPRS Report***

# **Science & Technology**

***Central Eurasia:  
Earth Sciences***

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# Science & Technology

## Central Eurasia: Earth Sciences

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**Antarctic Monitoring**

937N0025A St. Petersburg IZVESTIYA RUSSKOGO  
GEOGRAFICHESKOGO OBSHCHESTVA in Russian  
Vol 124 No 4, Jul-Aug 92 pp 351-354

[Article by A. N. Rogovtsev, St. Peterburg; UDC 914/  
919.9]

[Abstract] Environmental monitoring at the Soyuz and Druzhnaya-3 field bases of the 32d, 33d and 35th Soviet Antarctic Expeditions is described and evaluated. The field work made it possible to determine the territory of direct influence of human activities, to estimate the volumes and types of wastes and the volumes and types of discharge of pollutants. For example, the work at Soyuz field base during the 35th expedition had as its principal objective a clearer definition of environmental monitoring

elements for evaluating the impact of geological-geophysical work and auxiliary operations on the environment, including the monitoring of air and snow cover pollution. Analysis of snow cover samples for cadmium and lead revealed their increased content in comparison with the background and the data obtained during the 32d expedition. An analysis of the chemical composition of air samples indicated the presence of a broad range of trace elements which considerably exceeds their background levels. The observations clearly reveal that there is now a local anthropogenic impact on the environment due to operation of the Soyuz base which has a tendency to broadening and accumulation, as indicated by a comparison of the results of chemical analyses of snow cover and air samples collected during the 32d and 35th expeditions and also in comparison with background indices. References: 4 Russian.

### Marine Climatology

937N0057A Moscow DOKLADY AKADEMII NAUK  
in Russian Vol 328 No 3, Jan 93 pp 395-398

[Article by A. S. Monin, corresponding member, Russian Academy of Sciences, Oceanology Institute imeni P. P. Shirshov; UDC 551.583]

[Abstract] The present-day status of marine climatology is reviewed. The climate of the ocean has been studied much more poorly than atmospheric climatology because there have been but few continuous (or even fragmentary) series of measurements of the thermohydrodynamic characteristics of the ocean: the data files are many orders of magnitude smaller than for the atmosphere. The following are among the many aspects of the present-day status of the overall subject which are summarized (in a paragraph or a few sentences): global characteristics, vertical profiles, zonal profiles, azonal inhomogeneities, temporal variations (diurnal, synoptic, seasonal, intrasecular, etc.). Among the individual subjects discussed are: interaction between the ocean and the atmosphere; ocean surface temperature, density and salinity; direct and scattered solar radiation; evaporation, effective radiation and heat exchange with atmosphere; effects of climatic warming; water budget of ocean; upwellings, downwellings, synoptic eddies; CO<sub>2</sub> exchange between the atmosphere and ocean; typical oceanic stratification; profiles of various oceanic parameters; latitude zonality and azonality; inertial characteristics; seasonal and year-to-year variations; El Nino and other currents and their effects; climatic geography of small-scale processes in ocean, such as internal waves, vertical thin-layered microstructure, turbulence and intermittence. With respect to marine climatology, the author stresses that this field is only in the initial period of accumulation of empirical data. References: 15 References.

### Results of Experimental Soundings Using ADOMAS Self-Contained Bottom Magnetotelluric Station in Bering and South China Seas

937N0052A Moscow FIZIKA ZEMLI in Russian  
No 12, Dec 92 pp 88-93

[Article by V. V. Sochelnikov, S. A. Kisel, A. V. Kondyurin and R. N. Chzhu, Southern Division, Oceanology Institute imeni P. P. Shirshov, Russian Academy of Sciences; UDC 550.837.211]

[Abstract] A self-contained bottom magnetotelluric station designated the ADOMAS was developed by the Oceanology Institute in collaboration with the Physicomechanical Institute, Ukrainian Academy of Sciences. The station is for measuring the natural electromagnetic field at sea depths as great as 4500 m. The outfit consists of a two-component electrometer with Cl + Ag electrodes and a three-component ferrosonde magnetometer. The technical specifications include: threshold response of electric channels, 0.2  $\mu$ V/m; measuring range,  $\pm 2000 \mu$ V; response of magnetic channels, 0.1 nT; measuring range,  $\pm 60\,000$  nT; memory volume, 1.5 Mbyte; required power, 5 W; dimensions, 1.1 x 1.0 x 1.3 m; weight, 200 kg. ADOMAS measurements were made on the 42d cruise of the Dmitriy Mendeleyev in the Bering Sea and on the 16th cruise of the Akademik Aleksandr Nesmyanov in the South China Sea

at sea depths 540 and 40 m respectively. The instruments were connected to buoys by Kapron lines. The total duration of the records retrieved for each of the components was 27 hours for the Bering Sea and 19.5 hours for the South China Sea. The entire data processing procedure is summarized. Due to different physical and operational conditions more useful and reliable information was obtained for the Bering Sea than for the South China Sea, where some instrument malfunctions also occurred. Figures 5; references: 18 Russian.

### Hydrophysical Model of Turbulent Wake Beyond Seamount

937N0020C Moscow IZVESTIYA AKADEMII NAUK:  
FIZIKA ATMOSFERY I OKEANA in Russian  
Vol 28 No 9, Sep 92 pp 981-987

[Article by R. V. Ozmidov and V. N. Nabatov, Oceanology Institute, Russian Academy of Sciences; UDC 551.465.15]

[Abstract] Earlier research on deformation of geophysical fields and the turbulent wake near the top of Ampere seamount (depth of top of seamount only 55 m from the surface), carried out on several expeditions, is reviewed. On the "windward" side of the seamount there was an upwelling of dense deep waters, compensated by the subsidence of waters on both sides of the seamount. There was a quasistationary anticyclonic eddy around the seamount. There were also internal waves with a steepness close to critical in the neighborhood of the seamount. Near the top of the seamount, with flow around it, turbulence was generated which then was transported by the flow, forming a turbulent wake extending from the seamount along the direction of the current. On the average the intensity of turbulence in the wake decreased with an increase in distance away from the top of the seamount; the direction of wake propagation changed as a function of tidal phase. The turbulent wake beyond the seamount is simulated on the assumption that the turbulent energy generated near the seamount is expended on work against Archimedes forces and in dissipation. The expression derived for the dependence of the rate of dissipation of turbulent energy on distance to the seamount top is compared with experimental data. Figure 1; references: 8 Russian.

### Use of Seafloor Communication Cables for Estimating Lithospheric Resistivity

937N0019B Moscow FIZIKA ZEMLI in Russian  
No 9, Sep 92 pp 111-115

[Article by L. L. Vanyan, T. A. Demidova, I. V. Yegorov and A. A. Prokofyeva, Oceanology Institute imeni P. P. Shirshov, Russian Academy of Sciences; UDC 550.837.6]

[Abstract] Interest has recently increased in the use of seafloor communication cables for solving geophysical problems. A study was therefore made to ascertain what information on the resistivity of the oceanic lithosphere can be extracted from an analysis of the ionospheric-magnetospheric part of field strength on the assumption that it has already been discriminated from observational data. If the extent of the considered region is substantially less than the earth's size, the following assumptions are made: 1) the model is considered plane; 2) the horizontal magnetic field of ionospheric-magnetospheric origin is

uniform within the considered region. Usually there is a phase shift between the two orthogonal components of the geomagnetic field, which results in rotation of the vector of field strength in the horizontal plane. The formulated problem is examined in the example of an underwater cable connecting Sydney (Australia) and Wellington (New Zealand). The research revealed that the use of seafloor communication cables affords a fundamental possibility for estimating the resistivity of the high-resistance upper part of the oceanic lithosphere by an analysis of the ionospheric part of the strength between the ends of the cable. The principal steps in this procedure are outlined. Figures 4; references 3: 2 Russian, 1 Western.

### Range of Visibility of Underwater Objects

937N0054A Tomsk OPTIKA ATMOSFERA I OKEANA  
in Russian Vol 5 No 8, Aug 92 pp 789-811

[Article by E. P. Zege, I. L. Katsev and A. S. Prikhach, Physics Institute imeni B. I. Stepanov, Belarus Academy of Sciences, Minsk; UDC 535.36; 535.317.1]

[Abstract] This article gives a concise exposition of the optimal detection concept and its specific applicability in the method for computing the limiting ranges of detection and identification of objects in a scattering medium, including under water. A sequential exposition of the subject is presented. 1. On the basis of the optimal detection concept a mathematical formulation of the problem is given for finding the limiting ranges of television detection and identification of objects in a scattering medium; 2. A simple "ocean-atmosphere" system model is described which satisfies the conditions for a compromise between the number of input parameters of the system and the most precise description of the conditions for the propagation of radiation under different weather conditions in various zones of the seas and oceans; 3. Fundamental formulas are given for computing the signals, background and noise, in the computation procedures making it possible to attain a compromise between accuracy and computation time. Examples of solutions are given using such an approach for both some classical vision problems and for new problems related, in particular, to observations through the wave-covered sea surface. Both active and passive television systems can be used in this work. The programs are applicable on personal computers. Specific examples of computations of the limiting range of visibility are given. The generality of the concept and the modular principle for constructing the program make it possible, in case of necessity, to broaden its possibilities. Figures 8; references 27: 20 Russian, 7 Western.

### Effect of Increase in Range of Visibility of Underwater Objects With Rising Altitude of Observer Above Sea Surface

937N0054B Tomsk OPTIKA ATMOSFERA I OKEANA  
in Russian Vol 5 No 8, Aug 92 pp 840-842

[Article by L. S. Dolin and I. M. Levin, St. Petersburg Division, Oceanology Institute, Russian Academy of Sciences; Applied Physics Institute, Russian Academy of Sciences; UDC 551.463.5]

[Abstract] The effect of an increase in the range of bottom visibility with increased altitude of the observer above the surface of a water body is discussed (from an aircraft the bottom is more clearly visible than from aboard a ship; from space observations are still better). It has remained unclear what the physical nature of this effect is. The following considerations explain this effect.

1. With an increase in observation altitude the spatial fluctuations of the bottom image and surface are smoothed and decrease. 2. With an increase in H the range of visibility increases due to more perpendicular observation of sectors of the object plane lying at the edge of the field of view (the distance "along the ray" from the surface to the edge of the field of view decreases). 3. However, the principal reason for the improvement in visibility with an increase in H is that from great altitudes large objects are observed (for example, large sand shoals with a uniform reflection coefficient against the background of dark bottom sectors covered by algae which when observed from beneath the water or from low H do not fit into the field of view and therefore are not visible at all). It is shown that under the most favorable conditions the range of visibility of large high-contrast objects from space in the purest ocean waters may attain 500 m. References: 10 Russian.

### Mineral Resources of Ocean

937N0049A Moscow PRIRODA in Russian No 6, Jun 92  
pp 32-41

[Article by I. F. Glumov, academician, Academy of Technological Sciences RSFSR, chief, Section for Mineral Resources of World Ocean, Committee for Geology and Mineral Resources of the Russian Federation]

[Abstract] The importance and abundance of mineral resources of the world ocean are discussed. The history of development of interest in these resources and the initial experience in exploring these reserves are reviewed. The different aspects of international law involved in their future exploitation are examined. It is probable that their extraction on a commercial basis is impracticable prior to 2005-2010. Particular attention is given to the Clarion-Clipperton sector of the Pacific Ocean where such countries as the United States, USSR, Japan, France and China have already marked out their areas of priority interest. The text stresses the great value and characteristics of the deposits of highly concentrated ferromanganese nodules, cobalt-manganese encrustations and polymetallic sulfide ores, for whose exploitation ships and apparatus are now being developed, since the operations for their exploitation appear to be technically most feasible and whose extraction appears most likely to yield the highest profits. Some of the apparatus already developed and that which is in the planning and research stage in different countries is described. The exploitation of these resources will require careful ecological monitoring in order to evaluate impact on oceanic physical and biological parameters. Figures 5.

### Mathematical Description of Fine Structure Under Weak Variability Conditions

937N0060A Sevastopol MORSKOY  
GIDROFIZICHESKIY ZHURNAL in Russian No 3,  
May-Jun 92 pp 10-20

[Article by G. A. Moiseyev, Marine Hydrophysics Institute, Ukrainian Academy of Sciences, Sevastopol; UDC 551.46.087(261.4)]

[Abstract] The concept of weak variability of fields, meaning that with their measurement by some measuring instrument the signal at the instrument output is registered in the increment quantization interval, constituting one or more response quanta, is introduced. The description of such a field at small scales (microstructure) is given in terms of random discrete quantities reflecting the properties of both the measured field and the instrument. Theoretical relations expressing the probabilities of increments in composite intervals through the probabilities of increments in elementary intervals are derived for the case of independent random increments in elementary quantization intervals. The applicability of the model is illustrated by appropriate computations using data from microstructural measurements of the temperature profile in the main thermocline of the Sargasso Sea. This work revealed that at small scales a discrete description is natural for describing fine-structure variability in the ocean registered by real measuring instruments with a finite quantization and response interval. The random quantities at the instrument output reflect both the properties of the observed process and the instrument itself. A model of a step process with random independent increments, multiples of the instrument response quantum, can be used in the first approximation for describing fine structure under weak variability conditions. Figures 4; references 10: 8 Russian, 2 Western.

### Acoustic Characteristics of Waters of Northeastern Atlantic Ocean

937N0060B Sevastopol MORSKOY  
GIDROFIZICHESKIY ZHURNAL in Russian No 3,  
May-Jun 92 pp 74-79

[Article by N. P. Bulgakov, V. N. Belokopytov, P. D. Lomakin and V. N. Cheremin, Marine Hydrophysics Institute, Ukrainian Academy of Sciences, Sevastopol; UDC 551.463.2(261.1)]

[Abstract] In the Northeastern Atlantic there are two types of vertical large-scale acoustic structure of waters: a structure with two sound channels, formed under the influence of a Mediterranean intermediate water mass, and a structure in which in addition to the main deep underwater sound channel there is a powerful near-surface sound waveguide caused by winter thermal convection. The climatic boundary of the region with a two-channel system in the north reaches 56-57°N, in the west it extends to 28°W and in the south to 25°N. The structure with a waveguide associated with the upper convective layer occurs in the abyssal parts of the ocean along the coasts of Europe and the British Isles. In the cold half-year, as a result of the development of thermal convection, the northern boundary of the region with a two-channel type of structure is displaced southward to 40-43°N with a corresponding westward and northward broadening of the region with a waveguide in the convective layer. In the warm half-year advective transport restores two-channel stratification over the entire area to 60°N. The second type of structure is not characteristic for this season. The vertical hydroacoustic structure of intrathermocline lenses of Mediterranean origin qualitatively and quantitatively differs from the background structure of the speed of sound field. A well-expressed temperature inversion at the core of the lens, atypical for the background, causes an increase in the width and critical angle of the upper channel, as well as a deepening of the axis of the lower waveguide by 450 m in comparison with the background structure. Acoustic microwaveguides, caused by thermohaline intrusions, are observed on the lens periphery. Figures 3; references 9: 4 Russian, 5 Western.

### Statistical Analysis of Data From Sounding of Stratospheric Aerosol

937N0063A Moscow IZVESTIYA AKADEMII NAUK:  
FIZIKA ATMOSFERY I OKEANA in Russian  
Vol 29 No 1, Feb 93 pp 82-85

[Article by A. P. Ivanov, S. S. Khmelevtsov, A. P. Chaykovskiy and V. N. Shcherbakov, Physics Institute, Belarus Academy of Sciences; UDC 551.501.8]

[Abstract] Since 1985 specialists at the Belarus Physics Institute have used an ANB-314 lidar in laser sounding for experimental study of stratospheric aerosol. The intensity of backscattered radiation is measured at a wavelength  $\lambda = 0.532 \mu\text{m}$ . One measurement cycle takes about 30 minutes, making it possible to obtain a statistically sound echo signal profile to an altitude 30-35 km. Research on the spatial-temporal variability of the stratospheric aerosol layer requires determination of stable regularities in formation of the pertinent scattering profiles. This can be accomplished by application of the method of expansion of the random vectors into the eigenvectors of the correlation matrices. This simultaneously makes possible solution of the problem of compression of registered data without significant loss of information content. The dependence of the correlation radius  $\rho(h)$  on altitude is analyzed, revealing that there is a tendency to an increase in  $\rho(h)$  with an increase in altitude. The eigenvalues of the studied vectors are 39, 23 and 11% of their total sum. The first three vectors therefore reflect 73% of the variability (fluctuations) of the  $R(h)$  distribution of the investigated statistical set. The mean  $R(h)$  value and the three eigenvectors together make it possible to construct a stratospheric model of the  $R(h)$  distribution. Such processing makes it possible to discriminate characteristic layers in the atmosphere. Figures 4; references 5: 4 Russian, 1 Western.

### Generation of Plane Internal Waves by Moving Region of Atmospheric Disturbances

937N0063B Moscow IZVESTIYA AKADEMII NAUK:  
FIZIKA ATMOSFERY I OKEANA in Russian  
Vol 29 No 1, Feb 93 pp 106-112

[Article by S. F. Dotsenko, Marine Hydrophysics Institute, Ukrainian Academy of Sciences; UDC 551.466.81]

[Abstract] The plane problem of generation of internal waves in the ocean when there is uniform movement of a meteorological anomaly over its surface is investigated. Allowance is made for a continuous stable density stratification of the medium and planetary rotation and the meteorological disturbance is characterized by both anomalies of atmospheric pressure and the wind stress field. Internal waves accompanying moving atmospheric disturbances were earlier analyzed without joint allowance for these interrelated meteorological fields, planetary rotation or model density stratifications of the ocean. The considered problem is in a linear formulation using the hydrostatics approximation. The general properties of the baroclinic wave track are studied on the assumption that the ocean can be divided into two horizontal layers. In the upper quasihomogeneous layer an important role is played by turbulent friction, the lower layer is continuously density-stratified, but friction there can be neglected. In the

case of a nonstationary wind field a vertical velocity is induced at the lower boundary of the Ekman boundary layer which serves as a generator of internal waves in the layer of ideal fluid situated below. The wave amplitudes are computed for the mean density distribution in the Kuril-Kamchatka zone. It was established that wind stresses make a decisive contribution to the generation of internal waves. Figures 4; references 20: 15 Russian, 5 Western.

### Fractal Structure of Ozonometric Network

937N0063C Moscow IZVESTIYA AKADEMII NAUK:  
FIZIKA ATMOSFERY I OKEANA in Russian  
Vol 29 No 1, Feb 93 pp 140-142

[Article by A. N. Gruzdev, Atmospheric Physics Institute, Russian Academy of Sciences; UDC 551.501.71]

[Abstract] Although the global ozonometric network includes more than 100 stations, satellite measurements provide more complete and detailed information on the global distribution of ozone. However, data from satellite measurements are spatially inhomogeneous because the density of the revolutions is nonidentical in the near-polar regions and over the tropics. In order to obtain estimates of the fractal dimension of such a "network" it can be represented in the form of a regular latitudinal-longitudinal grid whose points of intersection can geographically characterize the points of satellite measurements. The fact that the surface ozonometric network and the latitudinal-longitudinal network simulating satellite ozone measurements have a dimension less than 2 may have important consequences. An observation network with such a dimension cannot register phenomena whose spatial distribution is characterized by the fractal dimension  $v_p < D - v$ . For the surface ozonometric network the detection limit is  $v_p = 2 - 1.67 = 0.33$ ; for the latitudinal-longitudinal network this value is  $v = 0.16$  at large scales but far greater (about 0.4-0.7) at small scales. If it is assumed (as in the case of geophysical fields) that the fractal dimension of the ozone field is a decreasing function of the ozone content (if strong anomalies are spatially more rarefied) an inadequately high fractal dimension of the observation network should result in a distortion of ozone statistics, in particular, an incorrect determination of spatially averaged values. Figures 3; references 9: 3 Russian, 6 Western.

### Model of Ozonosphere: Simulation Results

9370059A Moscow ASTRONOMICHSKIY VESTNIK  
in Russian Vol 27 No 1, Jan-Feb 93 pp 27-44

[Article by O. P. Krasitskiy and M. Ya. Marov, Applied Mathematics Institute imeni M. V. Keldysh; UDC 523.31-852]

[Abstract] The kinetics of photochemical processes in the ozone layer was investigated with allowance for anthropogenic pollution. The model problem was formulated within the framework of a spatially one-dimensional diffusional-photochemical model. A set of programs was prepared and an informational databank was organized. These programs make it possible to automate programming of the photochemical part of the model, including automated output of the results. Model computations

begin with calculation of the rates of chemical and photochemical reactions. The computed rates are substituted into the model equations and then, after linearization of the equations and with allowance for the boundary conditions, an approximate solution is found which is refined by iterations. The results are presented in the form of tables and graphs of the corresponding vertical profiles. Preliminary computations were made using the new, fully described diffusional-photochemical model. As examples, the results of three computations of the ozonosphere model are given: models A, B and C. Model A lacks anthropogenic chlorine-based pollutants. Model B corresponds to the present-day content of chlorofluorocarbons in the atmosphere and the present-day rates of ozone destruction by  $\text{Cl}_x$ . In model C the rates of entry of chlorofluorocarbons at the 1980 level were adopted as the lower boundary conditions. Model C therefore gives a prediction of the distribution of ozone and other atmospheric trace components after approximately 150 years when an equilibrium will be established between the entry of chlorofluorocarbons and their destruction due to solar UV radiation. The model computations show the destruction of the ozone layer by 4.3% due to anthropogenic pollution of the atmosphere by chlorofluorocarbons in the event of their entry into the troposphere at the 1980 intensity level. Figures 11; references 10: 3 Russian, 7 Western.

#### **Allowance for Shift of Absorption Line Centers of Atmospheric Molecules by Air Pressure in Problems of Transfer of Narrow-Band Optical Radiation**

937N0056A Tomsk OPTIKA ATMOSFERE I OKEANA  
in Russian Vol 5 No 9, Sep 92 pp 918-930

[Article by A. D. Bykov, Yu. N. Ponomarev and K. M. Firsov, Atmospheric Optics Institute, Siberian Department, Russian Academy of Sciences, Tomsk; UDC 535.34:551.508:621]

[Abstract] An analysis of the results of theoretical and experimental research on shifts of the absorption lines of small molecules present in the atmosphere is presented. Numerical experiments were carried out for taking into account the influence of the shift on the spectrum of resonance transmission for several types of vertical distribution of the concentration of absorbing gases and criteria are proposed for evaluating the influence of the magnitude of the shift of absorption lines on the propagation of narrow-band radiation in the IR and visible ranges. A series of tables gives the results of simulation for two shift values, four spectral resolution values and four Doppler half-width values. The tabulated data make it possible to analyze the role of shift of the line center on vertical atmospheric paths as a function of the following factors: vertical profile of concentration of absorbing gas; spectral range; spectral resolution. It is shown that for gases whose

concentration decreases rapidly with an increase in altitude there is a symmetric form of the resonance transmission spectrum, whereas for uniformly mixed gases the magnitude of the center shift is small, but the form of the spectrum has a clearly expressed asymmetry. It is confirmed that for gases of the  $\text{H}_2\text{O}$  type, whose concentration drops off rapidly as a function of altitude, there is a great shift of the center, but the form of the transmission spectrum is symmetric. A set of model curves is constructed which makes possible routine evaluation of the need for taking into account the shift of the line center by air pressure in problems relating to the propagation of resonance narrow-band radiation through the Earth's atmosphere. Figures 6; references 50: 13 Russian, 37 Western.

#### **Database for Coefficients of Shift and Broadening of $\text{H}_2\text{O}$ Absorption Lines in IR and Visible Spectral Regions**

937N0056B Tomsk OPTIKA ATMOSFERE I OKEANA  
in Russian Vol 5 No 9, Sep 92 pp 931-938

[Article by A. D. Bykov, Yu. N. Ponomarev and L. N. Sinitsa, Atmospheric Optics Institute, Siberian Department, Russian Academy of Sciences, Tomsk; UDC 535.34:551.508:621.375]

[Abstract] The results of implementation of the scientific program "Preparation of a Database for Coefficients of Shift and Broadening of  $\text{H}_2\text{O}$  Absorption Lines in the IR and Visible Spectral Ranges" are presented. The principal measurements of the half-widths and shifts of the vibrational and rotational absorption lines for  $\text{H}_2\text{O}$  in mixtures with nitrogen, oxygen, air and some other atomic and molecular gases were made using high-resolution laser spectrometers, including laser spectrophotometers with pulsed diode lasers, intracavity laser spectrometers based on wide-band solid-state lasers and two-channel optoacoustic spectrometers with pulsed and continuous lasers operating in the visible spectral range. The pertinent technical specifications are given for all the employed laser spectrometers. The computation methods also are described. An analysis revealed that the most important factor which largely explains all the experimentally observed dependencies of the shift of the  $\text{H}_2\text{O}$  absorption lines on the pressure of nitrogen, oxygen and air is the dependence of the dispersion part of the potential of the intermolecular interaction on the vibrational quantum number. For the vibrational-rotational lines in the visible spectral region the contribution of this mechanism is about 90%. For purely rotational lines the influence of this factor is equal to zero, but for the fundamental  $\text{H}_2\text{O}$  vibrational absorption bands in the IR range the corresponding contribution is comparable to the contribution of the principal term describing the electrostatic interaction between a dipolar water molecule and a perturbing molecule (nitrogen or oxygen), having a quadrupole moment. Figures 2; references 27: 5 Russian, 22 Western.

**Accuracy in Remote Sounding of Carbon Monoxide Using Second Harmonic of Radiation of TEA-CO<sub>2</sub> Laser**

937N0056C Tomsk *OPTIKA ATMOSFERY I OKEANA in Russian* Vol 5 No 9, Sep 92 pp 970-977

[Article by V. V. Zuyev, A. A. Mitsel and I. V. Ptashnik, Atmospheric Optics Institute, Siberian Department, Russian Academy of Sciences, Tomsk; UDC 551.501.7]

[Abstract] A study was made of the influence of the finite width of radiation of a laser pulse on the coefficient of differential absorption of CO when sounding by the path method using the second harmonic of a TEA-CO<sub>2</sub> laser. It is shown that with a laser mixture pressure of about 1 atm failure to take the spectral averaging effect into account may result in an error in determining the absorption coefficient, and therefore, the CO concentration, from 10 to 100%. A nontraditional method for the processing of sounding data is proposed for excluding this error. Estimates of the errors in determining the CO concentration which arise as a result of line shifts of the sounding radiation are given. With an increase in transmitter power it is possible to achieve a substantial increase in the length of the sounding path (up to 10 km) using a topographic target. In such a case the sensitivity in CO sounding may either decrease (in resonance interaction) due to the influence of the laser source spread function or increase (in the case of nonresonance interaction) if the power increase is associated with a simple increase in the pressure of the active medium of the TEA-CO<sub>2</sub> laser. The traditional method for processing sounding data registered using a TEA-CO<sub>2</sub> laser may lead to extremely significant errors in determining  $p_{CO}$  when there are strong CO variations characteristic for the atmosphere of a city with industrial or transportation effluent. The proposed nontraditional

data processing method requires a knowledge of the spectral composition of the radiation of the sounding pulses. Figures 4; references 11: 10 Russian, 1 Western.

**Instrumental Correction of Images Distorted by Scattering Medium**

937N0054C Tomsk *OPTIKA ATMOSFERY I OKEANA in Russian* Vol 5 No 8, Aug 92 pp 888-892

[Article by A. N. Alekseyev, V. V. Belov, B. D. Borisov and N. V. Molchunov, Atmospheric Optics Institute, Siberian Department, Russian Academy of Sciences, Tomsk; UDC 551.521+535.561]

[Abstract] Some results of use of an instrumental method for the correction of images distorted by scattering media are examined. The correction is based on the suppression of the scattered and amplification of the unscattered signal component. The results of laboratory experiments for observing objects through scattering media with the use of a newly developed electronic image correction block are given. A block diagram of the electronic system is given with 11 components identified. The results of instrumental correction and numerical filtering of images distorted by a scattering medium are compared. The initial object was a layout of three bright triangles with a dark spot at the center. Three different situations were studied: 1) a layer of increased turbidity borders on the object; 2) a layer of increased turbidity is situated between the object and the observer; 3) a layer of increased turbidity is situated near the observer. It was found that the inclusion of a contrast correction device in the registry channel exerts a positive influence on the formed image in all the optical-geometric observation situations, each of which is examined in detail. In addition, the filtering of the distorted images using the Tikhonov method and point scattering functions computed by the Monte Carlo method was carried out for each of the three mentioned situations and the results are compared. Figures 6; references: 11 Russian.

### Importance of Utilization of Industrial Production Wastes in Optimizing Ecological State of Environment

937N0062A *Novosibirsk GEOGRAFIYA I PRIRODNYYE RESURSY in Russian No 4, Oct-Dec 92 pp 42-49*

[Article by P. V. Ivashov and L. N. Pan, Water and Ecological Problems Institute, Far Eastern Department, Russian Academy of Sciences; Economic Research Institute, Far Eastern Department, Russian Academy of Sciences, Khabarovsk]

[Abstract] It is now recognized that the utilization of industrial wastes is a high-priority objective. As of 1989 the country annually extracts more than 15 billion tons of different kinds of mined raw material, ores of ferrous and nonferrous metals, coal, oil, gas, phosphorites, sulfates, potassium salts and construction materials, the vast majority of which after processing goes into waste heaps, although it is known that this volume even now could be reduced by 25%. This particular problem was examined in detail in the example of the Amur-Komsomolsk Technical-Industrial Complex (TIC) (area 100,000 km<sup>2</sup>) in the eastern part of the Baykal-Amur Mainline zone. The conditions prevailing at a whole series of industrial enterprises are discussed in detail relative to waste generation (volume) and disposal (areas occupied by wastes), with comments on various alternatives by which these wastes might be profitably exploited. The developed technological schemes, national and foreign experience, make possible virtually complete use of the wastes of mining, industrial, construction, chemical and fuel and power enterprises within the limits of the Amur-Komsomolsk TIC. Appropriate organizational measures and implementation of the recommendations on the processing of solid wastes outlined in the text will make it possible to improve environmental conditions and will provide the region with great quantities of secondary mineral raw material resources. References: 10 Russian.

### Ecological Structure of Natural Background of Irkutsk Determined From Space Survey Materials

937N0062B *Novosibirsk GEOGRAFIYA I PRIRODNYYE RESURSY in Russian No 4, Oct-Dec 92 pp 55-62*

[Article by T. I. Konovalova, V. S. Mikhayev and M. Shima, Geography Institute, Siberian Department, Russian Academy of Sciences, Irkutsk; Landscape Ecology Institute, Czechoslovakian Academy of Sciences, Ceske-Budejovice; UDC 911.2:528.77(571.53)]

[Abstract] The ecological structure of the natural background of Irkutsk and its neighborhood was studied using materials from a number of space scanner and photographic surveys. Processing was by both Russian and Czechoslovakian specialists using Pericolor systems and videoscanning cameras. The natural conditions of the Irkutsk region, where very special conditions prevail, are described in detail. Irkutsk itself annually releases into the atmosphere 22,000 tons of dust, 22,100 tons of sulfur oxides and 6300 tons of nitrogen oxides. Neighboring cities make an additional input and the polluted area measures as great as 100 x 350 km. The most polluted parts of the city coincide territorially with large industrial plants and the situation is worsened by heavy vehicular effluent.

A comparison of different surveys indicated that during the last 15 years there has been no substantial change in the zones of maximum pollution of the urban area. The thermal characteristics of urban land use were mapped and this revealed that zones of increased pollution and strong heating coincide. The area of the surrounding landscapes polluted by the city, determined from a space photograph taken in 1990 in the spectral range 0.7-0.8  $\mu$ m, was 3900 km<sup>2</sup>. Figure 1 shows the landscapes in the Irkutsk region; Figure 2 shows the zones of industrial pollution in Irkutsk; Figure 3 shows the thermal characteristics of urban land use structures in Irkutsk and its neighborhood; Figure 4 shows the structure of land use in the Irkutsk region. The collected data were used in formulating a series of proposals for improving the ecological situation in the city and its suburbs. Figures 4; references 7: 5 Russian, 2 Western.

### Atmospheric Self-Purification Climatic Potential. Experience in Evaluation at Different Scales

937N0062C *Novosibirsk GEOGRAFIYA I PRIRODNYYE RESURSY in Russian No 4, Oct-Dec 92 pp 160-165*

[Article by N. L. Linevich and L. P. Sorokina, Geography Institute, Siberian Department, Russian Academy of Sciences, Irkutsk; UDC 551.588.7(571.53)]

[Abstract] An overall evaluation of the natural capacity of the atmosphere for self-purification due to a definite combination of meteorological factors exerting an influence on it must correspond to the scale of the processes transpiring in the atmosphere. Several evaluation levels are defined: macroscale, regional, local and microscale. All these levels are examined, except for the last, for which sufficient information is lacking. Three important indices are employed as the basis for regionalization with respect to conditions for the dispersion of pollutants: atmospheric pollution potential (APP), atmospheric capacity for self-purification (ASPC) (the latter being far more important) and the climatic potential for atmospheric self-purification (CASPP). A CASPP evaluation was made for the territory of Irkutsk Oblast. A map (Fig. 1) shows the CASPP for this oblast; another map (Fig. 2) depicts the mesoclimatic potential for formation of air quality in the atmospheric surface layer. In this area, relatively uniform with respect to macroscale evaluations (APP, ASPC), by using regional methods it was possible to discriminate several gradations of climatic atmospheric self-purification potential. This provides a basis for a further breakdown of evaluations, which will make it possible to determine locations differing considerably with respect to conditions for formation of the quality of air in the surface layer. Figures 2; references: 8 Russian.

### Conception of System for Ecological Monitoring of Russia

937N0048A *Moscow METEOROLOGIYA I GIDROLOGIYA in Russian No 10, Oct 92 pp 5-18*

[Article by V. A. Kimstach, Sh. D. Fridman, Ye. S. Dmitriyev, L. S. Yazvin and Ye. Ya. Neyman, Committee for Hydrometeorology and Environmental Monitoring, Russian Federation; Institute of Global Climate and Ecology, Russian Committee for Hydrometeorology and Russian Academy of Sciences; State Institute for Applied

Ecology, Russian Ministry of Ecology; Geological Committee, Russian Federation; Central Specialized Inspectorate, Russian Ministry of Ecology; UDC 504.064.36:574.001.13(470+571)]

[Abstract] The environmental protection programs implemented during recent years in Russia have not resulted in stabilization of the situation, much less its improvement. This article stresses that the success of future programs is dependent on the efficiency in organizational monitoring of environmental protection activity and ecological safety. The concept of a Unified State Ecological Monitoring System for the Russian Federation is outlined. It is to be organized on the basis of development of the mechanism of interaction among departmental systems for monitoring objects in the environment and sources of anthropogenic impact with assurance of informational, methodological and metrological compatibility of these systems. The basis for the unified state system, ensuring reliability of data for the entire territory of Russia, is a base monitoring system which includes systems for monitoring the atmosphere, surface waters, sea waters, soils (Russian Committee for Hydrometeorology) and a ground water monitoring system (Committee for Geology). Figure 1 is a block diagram of use of monitoring in overseeing the state of the environment; Figure 2 is a diagram of functions and interrelationships at the local level in the Unified Ecological Monitoring Service; Figure 3 is a block diagram of the overall organizational structure of the system; a table gives the responsibility of different departments for monitoring sources of anthropogenic impact, environments and natural resources. These figures and table provide a basis for comprehending the structure and functioning of the proposed system described in detail in the text. Figures 3.

### Coastal Waters: Indicator of Economic Activity Along Black Sea Coast

937N0050A Moscow PRIRODA in Russian No 6, Jun 92 pp 17-24

[Article by A. F. Mandych, candidate of geographical sciences, head, Shore Geosystems Laboratory, Geography Institute, Russian Academy of Sciences, and S. I. Shaporenko, candidate of geographical sciences, senior scientific specialist, Shore Geosystems Laboratory]

[Text] Much has been written concerning the alarming trends in the state of the Black Sea and the environment in its basin. Particularly strong negative changes have occurred along the coasts and in coastal waters where the interaction between man and nature is manifested most sharply. The reasons for this are understandable: population increase, development of industry and agriculture, urbanization and intensive exploitation of all natural resources. Until now there have been no systematized evaluations of the impact exerted on the state of coastal waters by economic activity along the coast. In this article an attempt is made at partial filling of this gap. The analysis made during its preparation and the results which were obtained apply to the coasts of the Black Sea within the limits of Georgia, Russia and the Ukraine.

#### Anthropogenic Impact

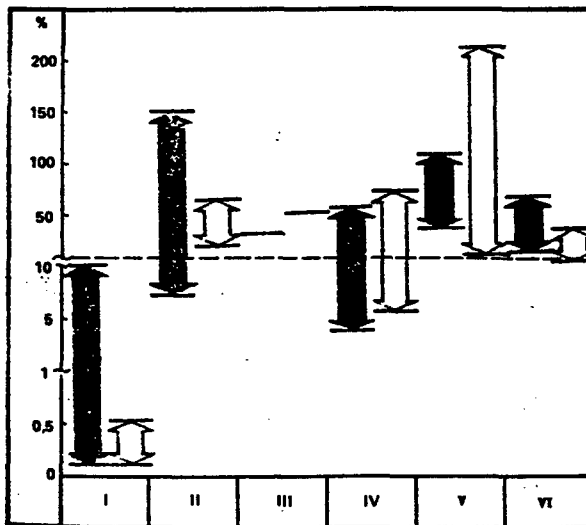
From the hydrological point of view the Black Sea basin can be regarded as a natural sea-land system. The key

process joining its different parts into an integrated whole is the water flows moving from extensive areas of the land into the sea. The sea is the closing element of the system, in integrated form reflecting the natural and anthropogenic changes in it. Man's impacts on the Black Sea can be divided arbitrarily into three groups.

The first of these is the economic activity in the drainage basins of the large rivers flowing into the sea, as a result of which there is a decrease in the inflow of fresh waters and a change in the chemical composition and volume of the fluvial sediments entering the sea.

Man's impact on drainage basins is most difficult to regulate because it is formed "at the output" from enormous socioeconomic structures having extreme inertia. For example, the withdrawal of water from large rivers flowing into the Black Sea, according to data for 1985, attained 3 km<sup>3</sup>/year and the trend of an increase in water consumption persists.

The second group is made up of economic activity on the coasts and in the coastal part of the sea. Its influence is reflected primarily in a change in the runoff of medium and small rivers, discharges of industrial waste waters and agricultural drainage waters, degradation of soils and the vegetation cover and their loss, as a result, of water conservation properties, pumping out of fresh ground water, urbanization of the territory, etc. The overall result of changes in the nature of coasts can characterize the degree of water flows from the land into the sea. In other words, changes in the quantity and quality of the waters entering the sea from the land can serve as generalized indicators of the impact of transformed economic activity on the land on coastal waters.



Variations in total nitrogen (black) and total phosphorus entering with waste waters (in % of annual runoff, averaged for entire period and for entire coast) along different sectors of Black Sea coast during 1984-1989. I) mouth of Danube; II) Odessa Bay; III) Dnepr-Bug lagoon (data for 1988); IV) Sevastopol Bay; V) southern shore of Crimea; VI) Caucasus coast.

It is arbitrarily possible to include in the marine coastal system that part of the sea waters which is under the strong influence of economic activity: construction of port and other structures in the coastal zone, production of mineral and biological resources on the shelf, reinforcement of shores, etc.

The sea and land parts of the coast are transformed in close interaction with one another. The more intense the economic activity is on the land, the greater is the anthropogenic impact on the coastal part of the sea. And, on the contrary, a change in the ecological state of the offshore waters exerts an influence on the population and economic activity on the coast. (The best-known example is the closure during recent years of beaches in virtually all regions of the Black Sea coast due to the pollution of coastal sea waters.)

Man's multicentury exploitation of the territory of Black Sea coasts and the use of their resources everywhere has led to considerable and usually unfavorable changes in natural conditions. This can be judged using the following examples.

The river runoff forming on the Danube-Dnepr coast is  $1.97 \text{ km}^3/\text{year}$ , whereas the unreturned economic use of natural waters in 1988 attained  $4.2 \text{ km}^3/\text{year}$ . The shortage of fresh water here is replaced from the artesian basin near the Black Sea and also from the Danube, Dnestr, Yuzhnyy Bug and Dnepr. The modern supply of the economy and population with water and especially its further development are made difficult by increasing environmental pollution. The seriousness of the situation, for example, is indicated by the content of toxic substances in the tissues of animals of the land and fresh water ecosystems of the Black Sea nature reserve, located in the southern part of Nikolayev and Kherson Oblasts and including part of the waters the Black Sea with its islands. For example, the DDT concentrations exceed the background level by a factor of 10, whereas the concentrations of polychlorodiphenyls exceed the background by a factor greater than 1000.

The consequences of environmental changes in the Crimea are for the most part related to the use of natural waters in agriculture and industry. Due to the inadequacy of local water resources in the Crimea water has been transferred from the Dnepr through the Northern Crimean Canal, constructed in 1963. As a result the runoff of drainage waters from the irrigation systems into Karkinit Bay of the Black Sea and Sivash salt lagoons and marshes of the Sea of Azov in 1985 attained 30% of the runoff of peninsular rivers into the sea.

The drainage waters here are enriched by biogenic substances and their mean annual mineralization is about  $1.8 \text{ g/liter}$ . The broad-scale use of chemical agents for the protection of plants considerably worsened the quality of ground and surface waters. In the aquifers of a number of regions in the Crimea pesticides have been detected in 90-100% of the samples; in 10-50% of the cases they exceeded the MAC.

In general man's influence on interaction between the land and sea in the Crimea was manifested very clearly in a

freshening of waters in Karkinit Bay and in the Sivash, pollution of coastal waters of the sea and entry of sea waters into the aquifers.

These examples show that economic impacts on the environment of coasts, and in particular, on the water budget of these territories, are comparable with the most powerful natural processes.

Finally, the third group includes direct activity in the waters of the sea itself, for the most part transportation and fishing.

Changes in the ecosystem of the deep part of the sea occur primarily due to the exchange of waters with coastal sea areas. (For the time being there is no evidence of a threatening state of the deep part of the sea, although hypotheses of a possible influence of anthropogenic factors on the dynamics of the upper boundary of the hydrogen sulfide layer in the sea have appeared.)

Thus, coastal sea areas play the role of a singular buffer smoothing the greater part of the anthropogenic influences from the land. However, when it is destroyed an ecological catastrophe in the sea will become inevitable.

#### Runoff of Biogenic Compounds

One of the serious consequences of man's activity on the Black Sea coast has been enrichment with some compounds and pollution of different natural media, including coastal sea waters.

Appreciable changes in the chemical composition of river waters began to be manifested in the mid-1960's. A particularly strong impact on the ecological state of the mouth reaches of rivers and coastal sea waters was the enrichment of the fluvial runoff of biogenic compounds, organic and toxic substances.

There was a considerable increase in the quantity of biogenic substances in the river waters entering into the northwestern part of the Black Sea. For example, the concentration of nitrites, nitrates and phosphates in the Danube, Dnestr and Dnepr by the beginning of the 1980's increased by a factor of 5-7 in comparison with the beginning of the 1950's and due to the increased natural abundance of water their runoff increased still more strongly.

During the second half of the 1980's, due to reduction in the use of mineral fertilizers in the river basins, improvement in the purification of waste waters entering the rivers and decrease in water consumption for economic needs, trends were noted to a decrease in the runoff of biogenic substances into the northwestern part of the Black Sea, although it remains far greater than in the 1950's.

The second source of an increase in the quantity of biogenic compounds in coastal sea waters is the waste waters of industrial enterprises, communal facilities and agriculture arriving directly from the coasts. This factor is playing an ever-increasing role and in some places is becoming decisive. For example, the entry of nitrogen into the sea with waste waters from the coasts in the 1980's was less by a factor of 200 than with the runoff of the Danube (2200 and 234,000 tons/year respectively), but almost the same as with the runoff of the Dnepr (2900 tons/year). The relation for phosphorus was close: 700 tons/year was

supplied by coastal waste waters, 60,100 tons/year by the Danube and 6900 tons/year by the Dnepr.

According to data from the Hydrometeorological Service for 1988 coastal runoff during the year brought in almost the same amount (1370 tons) as the Danube (1660 tons) and more than the Dnepr (960 tons).

Thus, at the present time the contribution from the coasts is comparable to the contribution of large rivers and evidently will increase still more if fuller allowance is made for sources, not only those within the limits of Russia and the Ukraine (we do not have data for Georgia).

An analysis of change in the annual runoff of total nitrogen and total phosphorus in waste waters along six sectors of the Black Sea coast indicated that with respect to the amplitude of variations of the quantity of nitrogen Odessa Bay stands out, whereas with respect to phosphorus it is the southern coast of the Crimea which is conspicuous, which may be evidence of the instability of purification of waters in these regions. However, the low annual runoffs of nitrogen and phosphorus in the mouth reach of the Danube indicate that most of the biogenic compounds and pollutants enter this river from the upper part of its drainage basin.

During recent decades there has been an increase in the flow of organic substances from the land into the sea due to

the broadening of production and the use of both natural and new synthetic compounds. Among them the most commonly present in sea water and the most dangerous for sea organisms are petroleum hydrocarbons, synthetic surfactants, phenols and chlororganic pesticides (table).

#### Dangerous Sea Pollutants

River runoff is the principal source of entry of petroleum hydrocarbons. Up to the mid-1980's pollution of river waters by them considerably varied and attained a maximum in 1985. That year their mean concentration was 340 µg/liter in the Danube and 430 µg/liter in the Dnepr (6.8 and 8.6 MAC values for reservoirs with fishing operations). Later oil pollution of the Danube and Dnepr decreased appreciably (changing considerably from year to year).

The source of petroleum hydrocarbons second in importance is industrial waste waters entering the sea along the entire coast. The concentrations of pollutants in them are hundreds of times greater than in river waters. According to an approximate and clearly understated estimate, the discharge of petroleum hydrocarbons with the waste waters of industrial enterprises and cities located along the coast, in the 1980's was about 1500-2000 tons/year, which is comparable to the contribution of the Dnepr and Danube in the years when their waters were relatively weakly computed.

Mean Annual Concentration and Annual Receipts of Pollutants With Danube and Dnepr Runoff

Name of substance	River	Units	1980	1981	1982	1983	1984	1985	1986	1987	1988	1989
Petroleum hydrocarbons	Danube	µg/liter	220	220	180	250	310	340	100	80	50	120
		thousands of tons	60.1	56.7	40.1	42.2	61.8	67.9	19.5	17	10.4	21.1
	Dnepr	µg/liter	350	220	60	120	390	430	200	330	190	160
		thousands of tons	20	13	3	5.7	13.6	22.1	10.4	12.1	8.7	5.4
Synthetic surfactants	Danube	µg/liter	40	—	—	40	45	25	15	25	25	25
		thousands of tons	10.9	—	—	6.8	10	5	2.9	6.3	2.5	4.4
	Dnepr	µg/liter	—	—	—	150	125	172	175	62	25	25
		thousands of tons	—	—	—	7.1	4.4	8.9	9.1	2.3	1.1	0.9
Phenols	Danube	µg/liter	—	—	—	—	—	2	3	5	5	5
		tons	—	—	—	—	—	399	584	1064	830	1056
	Dnepr	µg/liter	—	—	—	—	—	—	8	4	3	2
		tons	—	—	—	—	—	—	416	146	137	68
Chlororganic pesticides	Danube	ng/liter	—	—	—	80	171	382	27	83	n/d	5
		tons	—	—	—	13.5	34.1	76.2	5.2	17.7	n/d	0.88
	Dnepr	ng/liter	—	—	—	39	4	1	25	1	19	4
		tons	—	—	—	1.85	0.14	0.05	1.3	0.04	0.87	0.15

Note. The data under "river" are for the Danube and at the head of the Dnepr Liman. The dashes mean an absence of data, n/d means "not detected."

Petroleum hydrocarbons also enter the coastal waters due to "extraordinary events"—accidents to ships, as well as in the production and transport of petroleum products. In the total flow of pollutants the fraction of this source for the time being is small. However, during recent years along individual sectors of the coast (Odessa Bay, Batumi Bay) petroleum hydrocarbons are one of the principal causes of the oxygen deficit in sea water.

The mean annual concentration of synthetic surfactants in the mouth reach of the Danube in the first half of the 1980's varied in the range 40-45  $\mu\text{g/liter}$ . The maximum value (470  $\mu\text{g/liter}$ ) was registered at the delta "vertex" in April 1983. Beginning in 1985 their content in Danube waters decreased by almost half, but the runoff was reduced to 4400 tons/year.

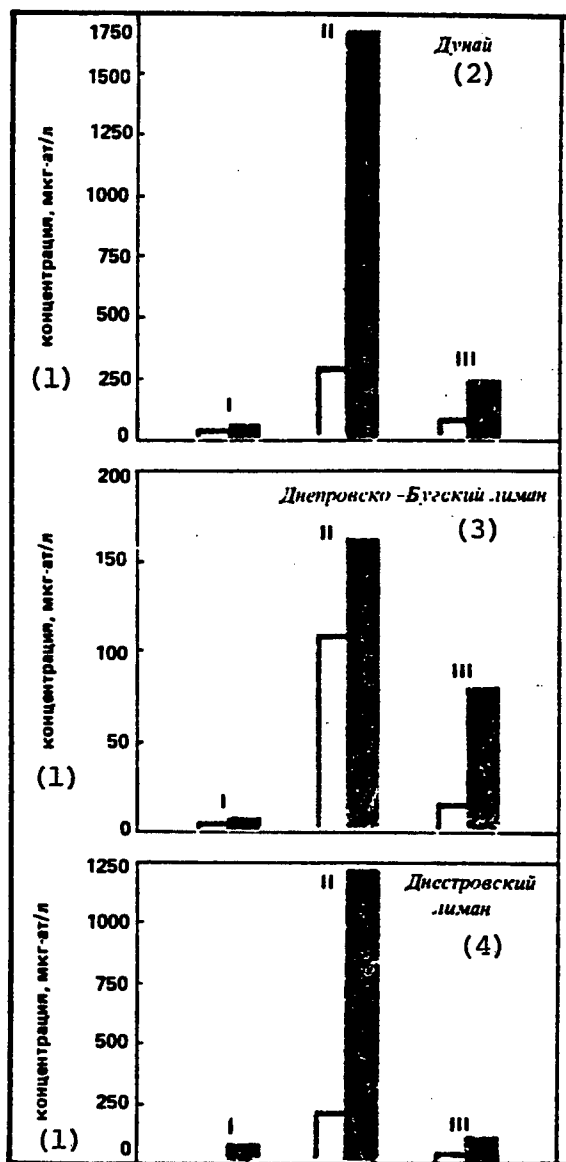
In the Dnepr the content of surfactants was considerably greater than in the Danube. During 1985-1986 the mean annual concentration exceeded 170  $\mu\text{g/liter}$  (the maximum in October 1985 was 565  $\mu\text{g/liter}$ ). In 1986 the runoff with Dnepr waters exceeded by three or more times the runoff with Danube waters. After 1988 the content of surfactants in Dnepr waters decreased to 25  $\mu\text{g/liter}$ , whereas the runoff was reduced to 900 tons/year.

A generalization of the data for 1980-1989 shows that in the 1980's as a yearly average surfactants entered the sea with waste waters to a greater degree than petroleum hydrocarbons (8300 and 1700 tons/year). The greatest (10,000-20,000 tons/year) runoff of surfactants was observed in 1981-1984 and most of this runoff entered Odessa Bay and Khadzhibeyevskiy Liman (lagoon). After 1985 the entry of surfactants into the sea was reduced to tens of tons. The pollution of coastal waters by surfactants due to accidents is less significant than due to petroleum products. During recent years, due to a decrease in the content of surfactants in river waters, pollution of shelf waters has been determined almost completely by runoff from the coast and sea ships in ports.

Like petroleum hydrocarbons and surfactants, phenols enter coastal waters from rivers and industrial runoff. Recently their mean annual concentration in the Danube has been 5-6  $\mu\text{g/liter}$ , in the Dnepr—2-3  $\mu\text{g/liter}$  and in the total runoff—about 1000 tons/year.

Information on the pollution of sea waters by phenols in waste waters is extremely limited and does not make it possible to determine the specific sources of their appearance in the sea. However, it can be noted that the coastal waters with an increased content of phenols are adjacent to industrial regions. For example, in the Odessa region the pollution of sea water by phenols intensified sharply after 1986 when their content attained 8-10 MAC for water bodies where fishing is carried out (1  $\mu\text{g/liter}$ ), but the maximum was 23  $\mu\text{g/liter}$ . During 1988-1989 the pollution of shelf waters by phenols was universal and its mean annual quantities in the Odessa region were 18-14 MAC, at the mouth of the Dnepr-Bug lagoon—4-6 MAC, in Karakinit Bay—16-18 MAC, in the coastal sector between the ports of Yuzhnyy and Ochakov—18-17 MAC, in the open northwestern part of the sea—16-11 MAC and in Yalta Bay—3-24 MAC. The least polluted by phenols (mean annual concentration not greater than 3  $\mu\text{g/liter}$ ) are the

coastal waters of the southern coast of the Crimea (other than Yalta Bay) and in the Pitsunda region.



Mean content of nitrogen and phosphorus in river runoff of Danube from 1948 through 1959 and from 1977 through 1983 (black) in Dnepr-Bug and Dniestr lagoons during 1952-1953 and 1977-1983 (white). I) nitrites; II) nitrates; III) phosphates (based on data from Yu. P. Zaytsev, et al., 1987).

Key: 1. concentration,  $\mu\text{g-at/liter}$  2. Danube 3. Dnepr-Bug Liman 4. Dniestr Liman

The use of pesticides (more than 150 kinds) on the Black Sea coast during the last four decades has become widespread (especially during 1965-1985). Their residues from fields entered rivers and ground water and directly from

the coasts entered the sea. Systematic observations of the content of pesticides in river (in the Danube and the Dnepr) and coastal waters began only in 1983. However, the content of only some pesticides was determined:  $\gamma$ -isomer of hexachlorocyclohexane (lindane), DDT and its metabolites, heptachlor and polychlorinated diphenyls. Accordingly, the cited estimates of coastal zone pollution are understated.

The runoff of pesticides with the waters of the Danube and Dnepr varies from year to year by a factor of tens, but by 1988-1989 there was a tendency to its decrease. However, considerably more pesticides are discharged with drainage and waste waters. For example, in 1985 0.46 ton of hexachlorocyclohexane alone entered Karkinit Bay from the fields of the Crimea (the Dnepr in this same year carried only 0.05 ton of pesticides of all types).

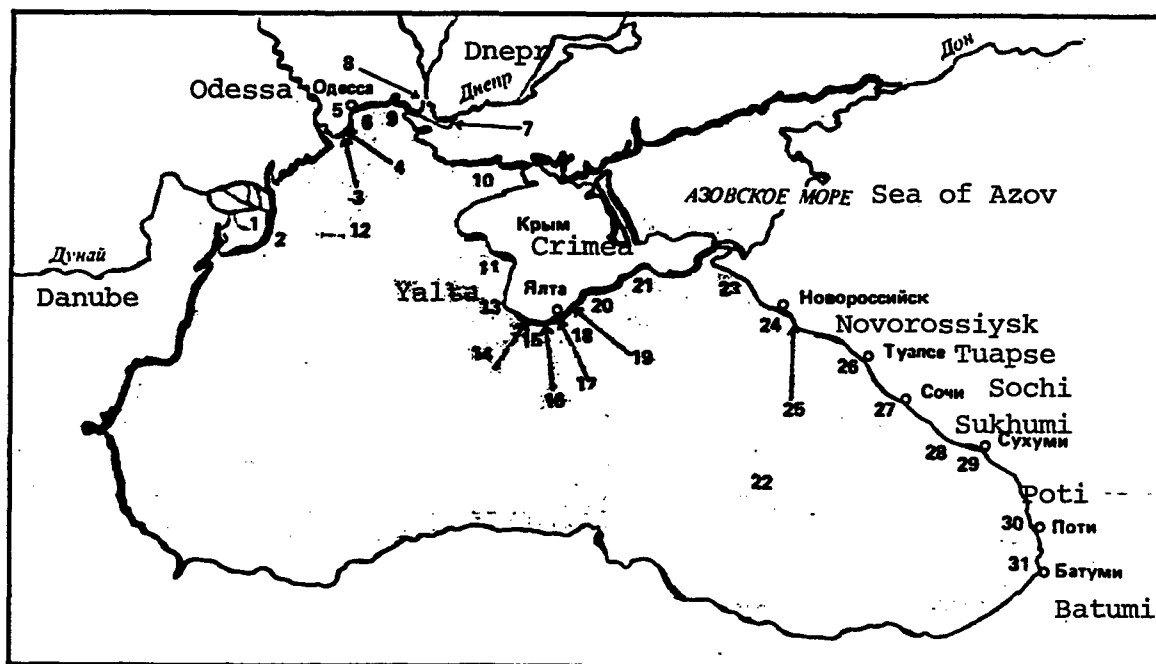
The impact of phenols and pesticides on sea organisms has been inadequately studied and it is not easy to evaluate their influence on the ecosystems of coastal waters with the observed concentrations. It can only be postulated that phenols begin to suppress hydrobionts with concentrations above 10  $\mu\text{g/liter}$ , but pesticides begin to exert such an influence with concentrations above 8-10  $\text{ng/liter}$ . The mean annual concentrations of phenols and chlororganic pesticides observed during 1983-1989 in most of the coastal regions, like petroleum hydrocarbons and detergents in the registered quantities, evidently for the most part stimulate eutrophication. However, in the Odessa region, in the coastal sector between the ports of Yuzhnyy

and Ochakov and in Karkinit Bay, where phenols and pesticides are present in the water, and in the open part of the northwestern region of the sea, phenols should exert a toxic effect on hydrobionts, although not to such a degree that the increasing trophicity of sea waters is appreciably reduced.

#### Integral Characteristic of Quality of Coastal Waters

In comparing different coastal water areas of the Black Sea by degrees of pollution it is possible to use an index taking into account the content of different chemical compounds. The index of the quality of sea waters (IQSW) proposed by the State Oceanographic Institute is determined using the formula:  $\text{IQSW} = \sum [\text{over } n] (C/\text{MAC})n$ , where C is the concentration of pollutant, MAC is its maximum admissible concentration, n is the number of pollutants. For the oxygen dissolved in sea water, in place of the ratio of the concentration to the MAC, use is made of the ratio of the norm to the real content. The norm is 6 in the case of a concentration above 6  $\text{mg/liter}$ , 12 in the case of 5-6  $\text{mg/liter}$ , 20 in the case 4-5  $\text{mg/liter}$ , 30 in the case of 3-4  $\text{mg/liter}$ , etc.

The entire range of change of the IQSW values can be arbitrarily broken down into seven classes of water quality: class I (very pure) corresponds to an  $\text{IQSW} \leq 0.25$ ; class II (pure) 0.25-0.75; class III (moderately polluted) 0.75-1.25; class IV (polluted) 1.25-1.75; class V (impure) 1.75-3; class VI (very impure) 3-5; class VII (exceedingly impure) above 5.



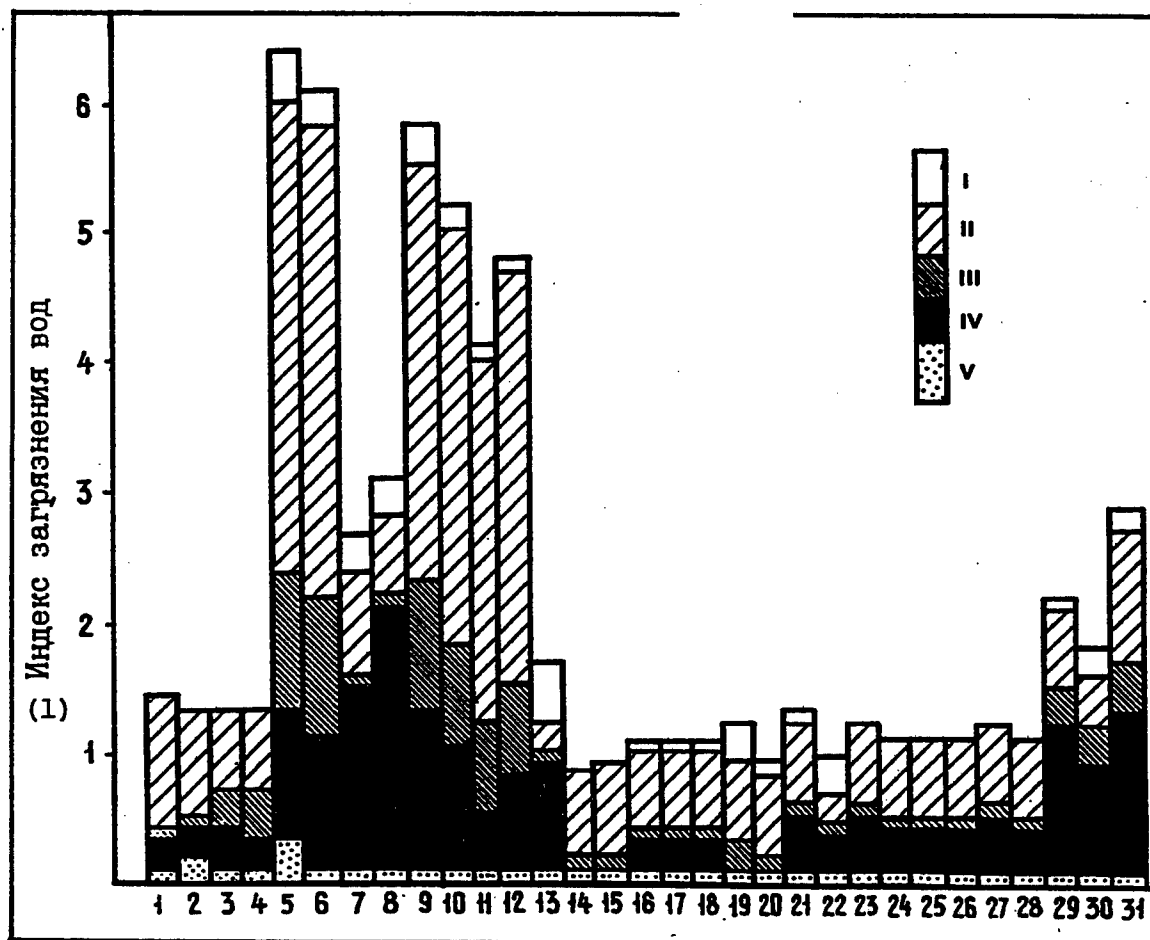
Map of sectors of Black Sea coastal zone for which sea water quality (pollution) indices were computed: 1) Danube delta; 2) Danube coastal sector; 3) Sukhoy lagoon; 4) entry channel for Illichevsk port; 5) Odessa port; 6) Odessa Bay; 7) Dnepr lagoon; 8) Bug lagoon; 9) coastal sector between Yuzhnyy and Ochakov ports; 10) Karkinit Bay; 11) Kalamit Bay; 12) open part of northwestern region; 13) Sevastopol Bay; 14) zone of resort water use of Alupka Bay; 15) open part of Alupka Bay; 16) near-port region of Yalta Bay; 17) zone of resort water use of Yalta Bay; 18) open part of Yalta Bay; 19) zone of resort water use of Gurzuf Bay; 20) open part of Gurzuf; 21) Feodosiya Bay; 22) open part of sea; 23) Anapa port region; 24) Novorossiysk port region; 25) Gelendzhik port region; 26) Tuapse port region; 27) Sochi port region; 28) Cape Pitsunda region; 29) Sukhumi port region; 30) Poti port region; 31) Batumi Bay.

We computed the IQSW for 31 sectors along the coasts of the Black Sea using the mean annual concentrations of pollutants for 1988. In this case in addition to the concentrations of dissolved oxygen in water the content of petroleum hydrocarbons, surfactants, chlororganic pesticides and phenols was taken into account. For Krasnodar Kray, where the content of phenols was not determined, the background value of their concentration in this region was used: 3  $\mu\text{g}$ . As the MAC for the total content of pesticides we arbitrarily used the background concentration for the sea—8 ng/liter.

An analysis of the IQSW values shows that along the coasts of Georgia, Russia and the Ukraine the water varies from moderately polluted to "exceedingly impure." With the great diversity of hydrological conditions along the coast, different with respect to the volume and composition of the flows of pollutants from the land and with an unidentical intensity of shipping, the coastal sectors, in accordance with the value of the index and the dynamics of the factors determining it, are reduced to six groups, described below.

Odessa region and coastal sector between ports of Yuzhnyy and Ochakov. The hydrological regime of coastal waters is determined here for the most part by river runoff freshening the upper layer. As a result, the vertical seasonal density gradients increase, which together with the shallow-water shelf and the difficulty in exchange of waters with the central part of the sea favors fishkills in the bottom layer.

The coastal waters in this region are the most polluted along the Black Sea coast. Their quality is influenced by the discharge of industrial and communal waste waters into the sea, the runoffs of the Dnepr and Yuzhnyy Bug, as well as intensive shipping. The quality of waters here is continuing to worsen for the most part due to an increase in the quantity of phenols in the waste waters of Odessa and an increase in the entry of surfactants and petroleum hydrocarbons into the sea along the coastal regions between the ports of Yuzhnyy and Ochakov.



Quality (pollution) index of coastal sea waters of the Black Sea in 1988 and relative contribution of different compounds to it: I) chlororganic pesticides; II) phenols; III) synthetic surfactants; IV) petroleum hydrocarbons; V) oxygen. The figures designate the numbers of the sectors of coastal waters shown on the Black Sea map (based on data from the *Yezhegodnik kachestva morskikh vod po gidrokhimicheskim pokazatelyam za 1988 g.* (Yearbook of Sea Water Quality Based on Hydrochemical Indices for 1988).

Key: 1. Water pollution index

Coastal areas of Danube, Dnepr and Bug lagoons. The pollution of coastal waters here is greatly influenced by regulation of the runoff of the Danube, Dnepr and Yuzhnyy Bug and the quality of their waters. The coastal areas of the Danube for the most part are polluted by phenols and the mouth regions of the Dnepr and Yuzhnyy Bug by petroleum hydrocarbons. During recent years there has been an appreciable improvement in the quality of waters, which now corresponds to the "polluted"- "impure" classes.

Karkinit and Kalamit Bays. The principal pollution sources are industrial waste waters and drainage waters of Crimean irrigation systems. During recent years in the bays, for the most part due to an increase in the entry of surfactants and petroleum hydrocarbons, there has been a sharp worsening in the quality of the waters, which today are classified as "exceedingly impure."

Sukhoy lagoon. Sevastopol Bay. In these sea areas, with insignificant river runoff and relatively isolated from the open part of the sea, the main pollution sources are shipping, industrial and communal waste waters. Most of the pollutants are phenols and petroleum hydrocarbons. The quality of the waters corresponds to the "polluted" and "impure" classes.

Southern shore of Crimea, Krasnodar Kray and Cape Pitsunda region. These are the cleanest parts of the Black Sea coastal zone. The water here belongs to the "polluted" class. The influence of river runoff on the quality of coastal waters is small. The principal pollutants along the southern shore of the Crimea are phenols arriving with communal waste water, but in some sectors chlororganic pesticides and detergents are most important. In Krasnodar Kray there is a predominance of petroleum hydrocarbons from the purification structures of petroleum refineries and ports, from ships and from urban runoff.

Waters near Sukhumi, Poti and Batumi ports. These are characterized by relatively free water exchange with the open part of the sea. The waters are polluted by industrial and communal waste waters, as well as by ships. Fluvial runoff exerts a periodic influence on water quality. The principal pollution component is petroleum products, an increased content of which sometimes results in the development of hypoxia in Batumi Bay. The water in Sukhumi Bay and in the Poti port region belongs to the "impure" class, and the water in Batumi Bay to the "very impure" class. In general the spatial variability of the quality of sea waters along the Black Sea coasts is not random and correlates well with the flows of pollutants from the coast. For example, in the northwestern part Odessa Bay, the coastal sector between Yuzhnyy and Ochakov ports, Karkinit and Kalamit Bays, and also the open waters, are exceedingly strongly polluted. The higher pollution here than in the mouth reaches of the large rivers (delta and coastal sectors of the Danube, Dnepr and Bug lagoons), quite clearly demonstrates the influence exerted on the state of coastal waters by economic activity on the shore.

If it is assumed that in the immediate future all the countries of the Black Sea basin adopt a strategy for attaining ecologically safe norms for the runoff of the large rivers flowing into the Black Sea and if it is successfully realized, a positive effect will be manifested in the best case after a decade.

It is more realistic to carry out the necessary environmental measures within the limits of the sea-land system, the coast. They must include ecologically safe water use, the removal of unecological production facilities beyond the coastal area, planned organization of natural-anthropogenic landscapes coming as close as possible to natural landscapes. All this assumes a fundamental change in environmental use, its organization on new economic principles. This is both difficult and expensive. But only such a path can lead to stabilization of ecological conditions in the Black Sea.

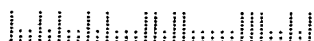
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